EMCON

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April 22, 1997
Project 40936-026.001

Mr. Doug Pierce
Washington State Department of Transportation
Maintenance Office
310 Maple Park East
Olympia, Washington 98504-7358

Re: Final Report, Geotechnical Evaluation of Landslide Near SR-3 and Gorst Creek
Gorst, Washington

Dear Mr. Pierce:

Enclosed are two copies of the final report presenting findings of a geotechnical evaluation of the landfill slope failure near SR 3 and Gorst Creek south of Gorst, Washington. The evaluation was performed by EMCON's subcontractor Hong West & Associates, Inc. (HWA) consistent with the scope of work presented in our proposal to the Washington State Department of Transportation (WSDOT) dated April 9, 1997.

The purpose of the evaluation was to evaluate short term measures that could mitigate impacts from further landsliding of the landfill and protect the nearby SR 3 highway embankment and box culvert. HWA's report presents two alternatives for short term measures that can be implemented to achieve this purpose. Both of the alternatives entail building a catchment wall/barrier near the down slope terminus of the slide to prevent landslide debris from entering the creek. Implementing either of these alternatives should minimize the potential for landslide debris to block the box culvert beneath the SR 3 embankment while a long term slope stabilization measure is identified and implemented.

Based on the information provided in HWA's report, EMCON has prepared rough estimates of the construction costs for each alternative. The construction costs do not include permitting costs, mitigation of impacts to the creek during construction or removal of the short term measure after the long term measure is constructed. Approximate construction cost for each alternative is provided below:

| | |
|---|---|
| Alternative A - Gabion Catchment Wall | $20,000 to 25,000 |
| Alternative B - Rock Debris Barrier | $15,000 to 20,000 |

The actual construction costs for either alternative will greatly depend on how much work will be required to provide access to the location of the catchment walls/barrier for equipment and material delivery.

EMCON appreciates the opportunity to be of service on this project. If you have any questions, please do not hesitate to call.

Sincerely,

EMCON

Brian O'Neal for:

Daniel A. Balbiani, PE
Project Manager

Attachments: Geotechnical Evaluation

cc: Mr. Andre Mare, Hong West & Associates, Inc.

HWA
HONG WEST
& ASSOCIATES, INC.
Geotechnical Engineering
Hydrogeology
Geoenvironmental Service
Testing & Inspection

April 22, 1997
HWA Project No. 97063

EMCON
18912 North Creek Parkway
Bothell, Washington 98011

Attention: Mr. Daniel A. Balbiani, P.E.

Subject: **Geotechnical Evaluation**
**Gorst Creek Landslide**
**SR-3 at Gorst Creek**
**Gorst, Washington**

Dear Mr. Balbiani:

In accordance with your request, Hong West & Associates, Inc. (HWA) completed a geotechnical evaluation of the slope failure south of Gorst, adjacent to State Highway 3. Our work included a site reconnaissance, topographic surveying and mapping, developing profiles through the slide area, and providing recommendations relating to the protection of the SR-3 highway embankment and containment of slide debris.

## SITE AND PROJECT DESCRIPTION

The site is located adjacent to the southeast side of SR-3, approximately 2 miles south of Gorst, and 1 mile north of the Bremerton airport, as shown on the Vicinity Map, Figure 1. We understand that, on or near March 20, 1997, during a major storm event, the NW facing slope on the perimeter of a privately-owned landfill failed. The landslide deposited soil and landfill debris at the base of the approximately 50-foot-high slope. A small stream, Gorst Creek, passes through the base of the landfill. A circular steel culvert reportedly extends under the landfill and was buried by slide debris. Flow is continuing through the slide debris. Figure 2 shows the site topography in the vicinity of the slide and Figure 3 shows a cross-section through the slide.

About one hundred feet west of the toe of the landslide, Gorst Creek passes under State Highway 3 through a fill embankment in a 4'x4' concrete culvert. During or following the storm event, high flows in the creek washed landslide debris downstream, depositing garbage on both sides of the highway and inside the culvert.

We understand that a current concern of WSDOT is the potential for future landsliding to wash debris into and against the culvert, thus blocking stream flow and threatening the

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stability of the highway embankment. The intent of the recommendations in this report are to provide short-term, 'emergency' measures to contain additional slide debris from moving downstream. We understand that, following the rainy season, a permanent landslide repair may be implemented. This report discusses possible permanent repair scenarios in addition to short-term containment measures. Subsurface explorations were beyond the scope of this study, and thus slope stability cannot be adequately evaluated at this time. Permanent construction to improve stability should not be performed without adequate investigation, which would include subsurface exploration and performance of slope stability analyses.

## SITE CONDITIONS

HWA made visits to the site on April 3 and April 4, 1997, and surveying was performed on April 10 and 11. During our site reconnaissance, we noted surface features, natural soil exposures, and drainage conditions. A summary of our observations is presented below.

The landslide consists of a steep scarp, approximately 20 feet in height, with debris (garbage) deposited on the lower slope as shown on Figures 2 and 3. The scarp exposes garbage from the landfill, while the lower portion of the slide is garbage debris mixed with sands and gravels.

Results of our reconnaissance indicate that native soils at the toe of the slope likely consist predominantly of glacial outwash sands and gravels. On the higher slopes towards the outer edge of the failure, thinly bedded, dense silts and fine sands were noted.

During our site visit, water was seeping from the base of the slope in several locations. Seepage likely originates from the permeable soils near the base of the landfill and/or from the buried culvert. It is possible that the culvert is partially or completely blocked, with stream flows finding an alternate path under the landfill.

Erosional gullies were noted at the top of the landfill. The high flows in the creek bed during the storm were likely a combination of overland flow down the slope, stream flow under the landfill, and seepage from the slope face.

Although no apparent signs of continued slope movement were noted during our reconnaissance, additional slope failures could occur. If future sliding occurs, it will likely be sloughing of the upper portion of the landslide scarp; however, future large-scale events cannot be ruled out. Even without slope failure, continued transport of sediment and debris downstream is likely during heavy rainfall events.

## CONCLUSIONS AND RECOMMENDATIONS

The following sections present recommendations to prevent the downsteam movement of debris and protect the highway embankment. Two alternatives have been identified.

### ALTERNATE A - GABION CATCHMENT WALLS

Two gabion catchment walls could be constructed downslope of the failure, at the approximate locations shown on Figure 4. The walls should consist of gabion rock filled baskets, with gabion filled aprons on the downstream side, as shown on Figure 5. For this project, the primary advantage of the gabion wall system over other wall systems is its inherent permeability which allows both free drainage and earth retention. Other advantages include its relatively low cost, its ability to accommodate some movement without loss of structural integrity, and its constructibility in areas of poor access.

The proposed downstream (western) gabion wall is intended as a 'second-defense', should the upstream wall overtop or collapse in the event of a major landslide. The upstream catchment wall is the primary barrier to debris from erosion of the exposed face and from sloughing of the headscarp.

Construction Recommendations - Site Specific

- Excavate the loose material 1 to 2 feet below the ground surface or until a stable foundation surface is reached.
- Gabion wall blocks should be 3 feet square in cross section and filled with 6"-8" rock, as shown on Figure 5.
- The upstream wall should have a top-of-wall elevation of about 74 feet (based on assumed datum, see Figure 2) and the downstream wall about 70 feet. The wall height will vary along the length of each wall, but should be about 3 gabions high at the stream centerline of the upstream wall and 2 gabions high at the centerline of the downstream wall. Gabion walls should not be constructed more than 3 stacks high (9 feet) unless additional blocks are provided at the base for added stability.
- To control scour in the vicinity of the wall, it should be placed on a 9-inch thick gabion apron, filled with 3"-6" rock, extending downstream as shown on Figure 5. The gabion wall should be tied into the gabion apron in accordance with the manufacturer's recommendations. Additionally, a 12-inch thick layer of 3"-6" rock should be placed upstream a distance of 6 feet from the wall.
- Although the recommended gabion walls are extremely permeable, a culvert could be placed beneath the wall at the stream centerline to provide an additional conduit for

water. We anticipate an 18" diameter culvert would be sufficient. The upstream end of the culvert should be screened to prevent the passage of debris.

Construction Recommendations- General

- Gabions should be designed and installed in accordance with manufacturers standards and specifications and the recommendations of this report.
- Gabions should be fabricated in such a manner that the sides, ends, lid and diaphragms can be assembled at the construction site into rectangular baskets of the sizes specified.
- Gabions should be of single-unit construction; the base, lid, ends and sides should be either woven into a single unit or members connected in such a manner that the strength and flexibility at the connecting points is at least equal to that of the mesh.
- Where the length of the gabion exceeds 1.5 times its horizontal width, the gabion should be divided by diaphragms, using the same mesh and gauge as the body of the gabion, whose length does not exceed the horizontal width of the gabion.
- Gabion aprons are unfolded and assembled. Corners are first joined together and then the diaphragms are attached to the side panels.
- Each gabion should be assembled by tying all untied edges with lacing wire or approved fasteners. The lacing wire should be tightly looped around every other mesh opening along the seams in such a manner that single and double loops are alternated.
- Gabions should be filled to a depth of 12 inches and then two connecting wires should be tightly tied to opposite faces of each gabion cell at a height of 12 inches above the base. Gabions should then be filled with an additional 12-inch layer of rock fill and similarly tied at this level with two connecting wires. Then gabions should be filled to the top. The tops of the gabions are then closed along edges and diaphragms using lacing wire or approved fasteners. Keep voids and bulges in the gabions to a minimum in order to ensure proper alignment and a neat, compact, square appearance.

**ALTERNATIVE B - ROCK DEBRIS BARRIER**

Construction of a rock debris barrier is another alternative that, although more material intensive, may be less labor intensive than the gabion option. The barrier would essentially be a semi-permeable dam with the upstream and downstream slopes inclined approximately 1H:1V, and located at the upstream gabion wall location. Construction recommendations for a rock debris barrier are presented below and illustrated on Figure 5.

- Rock for the barrier should be 8" to 24" quarry spalls.

- The barrier should be placed upon a foundation of 3"-6" rock, 12 inches thick, and extending 6 feet upstream and downstream from the face of the barrier, as shown on Figure 5.
- The elevation at the top of the barrier should be about 74 feet (assumed datum, see Figure 2).
- A culvert should be placed beneath the wall at the stream centerline to provide an additional conduit for water. We anticipate an 18" diameter culvert would be sufficient. The upstream end of the culvert should be screened to prevent the passage of debris.

## QUANTITY ESTIMATES

We made rough estimates of material quantities required for each alternative, as shown in the following table.

| Material | Volume, cubic yards | | |
|---|---|---|---|
| | Alternative A | | Alternative B |
| | Upper Wall | Lower Wall | |
| 3"-6" Rock | 28 | 18 | 44 |
| 6"-8" Rock | 28 | 13 | ----- |
| 8"-24" Rock | ----- | | 84 |
| Total Rock Volume | 87 | | 128 |

## SITE ACCESS

Access to the creek bed will involve traversing slopes with approximate inclination of 1½H:1V. If access is from the highway side of the project, a track will need to be cut across the slope, starting from the highway north of the embankment and extending to the toe of the landslide. This will require some earthwork and probably tree removal. Another option to minimize site impacts would be to dump rock at the top of the highway embankment, directly above the culvert. Rock would then be directed downslope, possibly using a plywood chute. A track-mounted backhoe could be lowered down the embankment on a cable. With this option, disturbance would be limited to that caused by the backhoe transporting materials along the edge of the stream. This option may require lane closure and traffic control on SR-3.

### Inspection and Maintenance

Debris barriers and catchment walls should be inspected following major rainfall events, and debris removed as appropriate. Structural damage caused by storm events should be repaired as soon as possible to prevent further damage. We recommend a steel grate (trash-rack) be placed across the culvert to further prevent the culvert from filling with debris.

### Long-Term Repair

Measures to improve the stability of the landfill side slope must include effective surface and subsurface drainage control measures. This may include trench interceptor drains extending into the debris at the base of the slide. Additionally, the existing end-of-culvert under the landslide would be excavated, examined, and possibly tightlined further downstream. Surface water courses at the upper land should be studied so that the overland flows can be controlled or collected, and tightlined to the creek bed.

Potential repair scenarios include a soil buttress or combination retaining wall with buttress slope above. Slope inclination would not exceed 2H:1V unless slope reinforcement is provided. Buttresses would be benched, or "keyed" into the existing slope.

## UNCERTAINTY AND LIMITATIONS

As previously discussed, the intent of the recommendations herein are to prevent future downstream movement of debris. The gabion walls and rock dam proposed in this report have not been designed to prevent the occurrence of or withstand the full force of another major landslide. We anticipate that future upslope movement may occur, particularly during heavy storm events. In order to adequately address stability of the slope and provide appropriate recommendations for long-term stability, it will be necessary to perform additional studies.

Experience has shown that soil and groundwater conditions can vary significantly over small distances. If, during future site operations, subsurface conditions are encountered which vary appreciably from those assumed herein, HWA should be notified for review of the recommendations of this report, and revision of such if necessary.

Within the limitations of scope, schedule and budget, HWA attempted to execute these services in accordance with generally accepted professional principles and practices in the fields of geotechnical engineering and engineering geology at the time the report was prepared. No warranty, express or implied, is made. The scope of our work did not include environmental assessments or evaluations regarding the presence or absence of hazardous or toxic substances in the soil, surface water, or groundwater at this site.

We appreciate the opportunity to provide geotechnical services on this project.

Sincerely,

HONG WEST AND ASSOCIATES, INC.

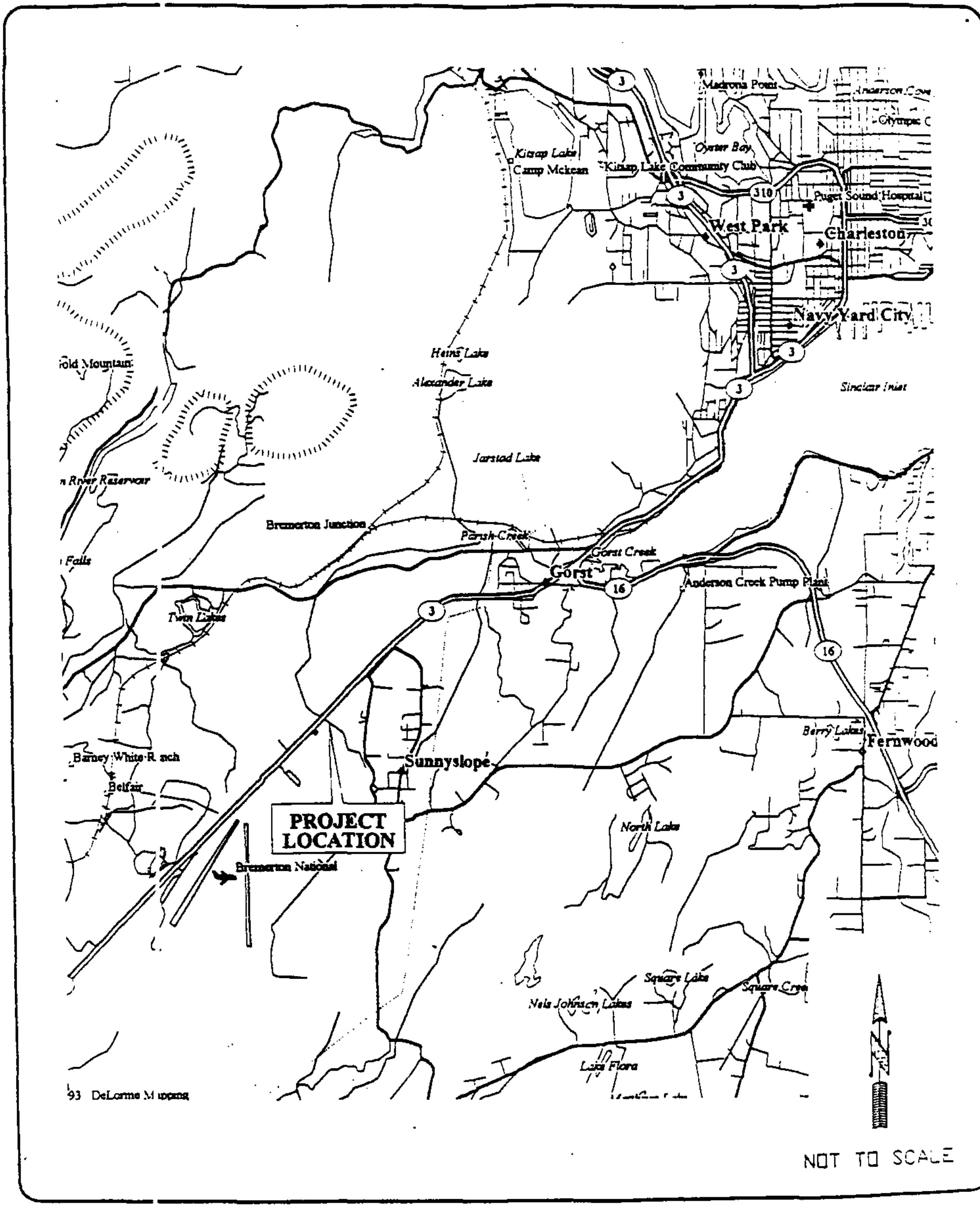
ANDRE D. MARE
STATE OF WASHINGTON
31074
REGISTERED
PROFESSIONAL ENGINEER
EXPIRES 9/22/98

4/22/97

Sa H. Hong, P.E.
Principal Geotechnical Engineer

André D. Maré, P.E.
Geotechnical Engineer

ADM:SHH:adm




HONG WEST & ASSOCIATES, INC.

GORST CREEK LANDSLIDE
GORST, WASHINGTON

VICINITY MAP

PROJECT NO.: 97063

FIGURE: 1

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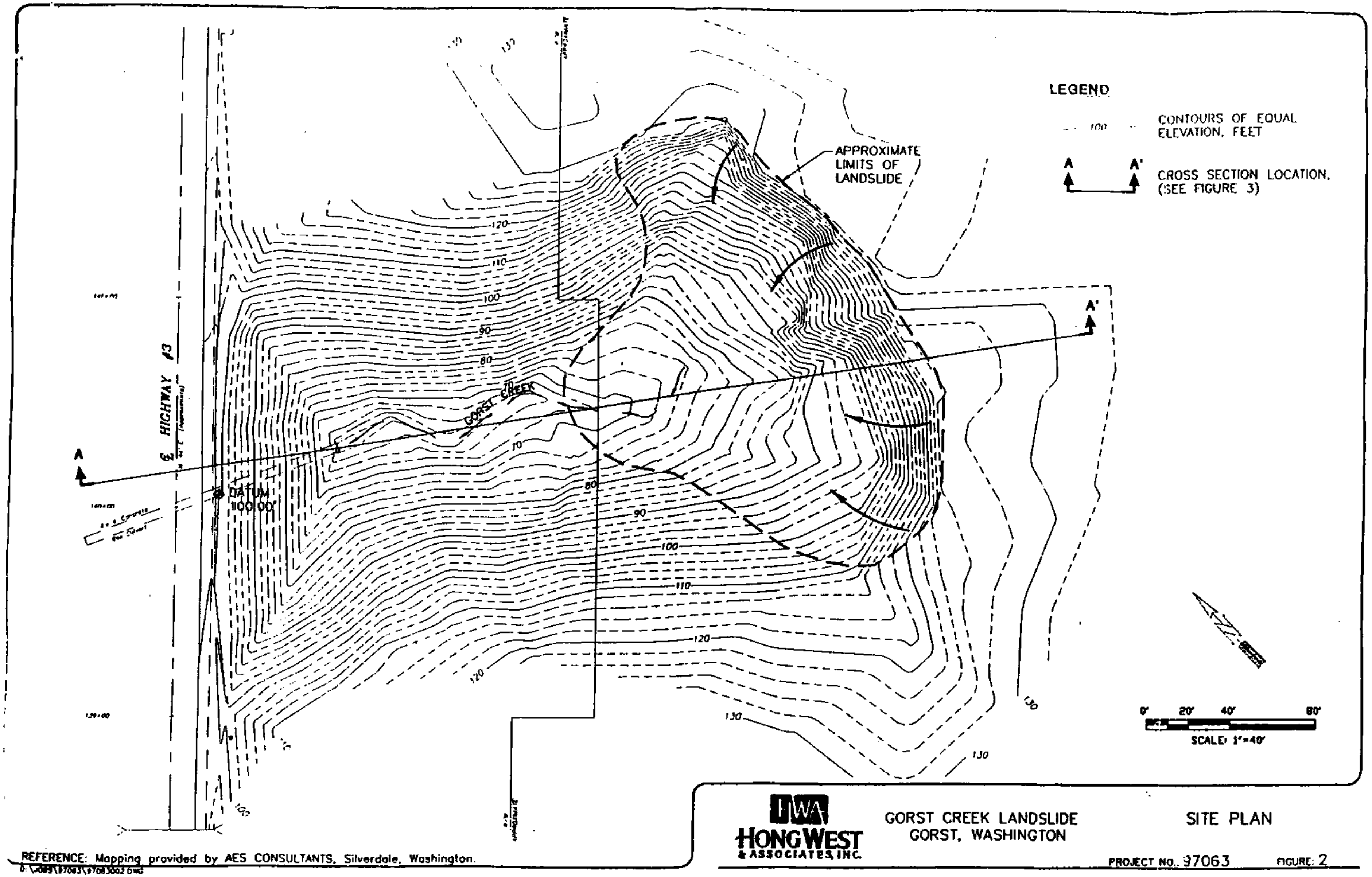
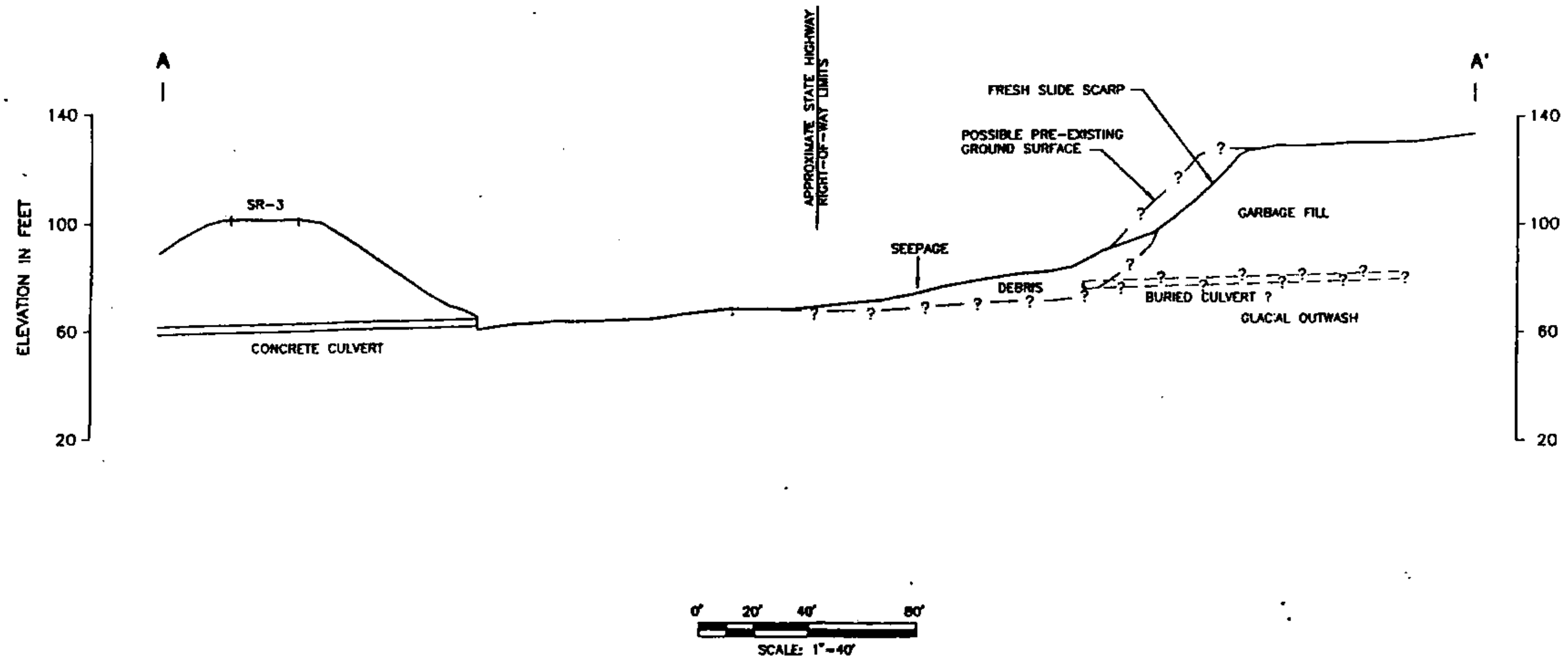

LEGEND
100
CONTOURS OF EQUAL ELEVATION, FEET
A A'
CROSS SECTION LOCATION, (SEE FIGURE 3)
APPROXIMATE LIMITS OF LANDSLIDE
HIGHWAY #3
GORST CREEK
DATUM 100.00'
A
A'
70
80
90
100
110
120
130
0' 20' 40' 80'
SCALE: 1"=40'
HONG WEST & ASSOCIATES, INC.
GORST CREEK LANDSLIDE
GORST, WASHINGTON
SITE PLAN
PROJECT NO. 97063
FIGURE: 2
REFERENCE: Mapping provided by AES CONSULTANTS, Silverdale, Washington.




**NOTE**

DATUM ASSUMED = 100.00 FEET AT SHOULDER OF SR-3 AS SHOWN ON FIGURE 2.

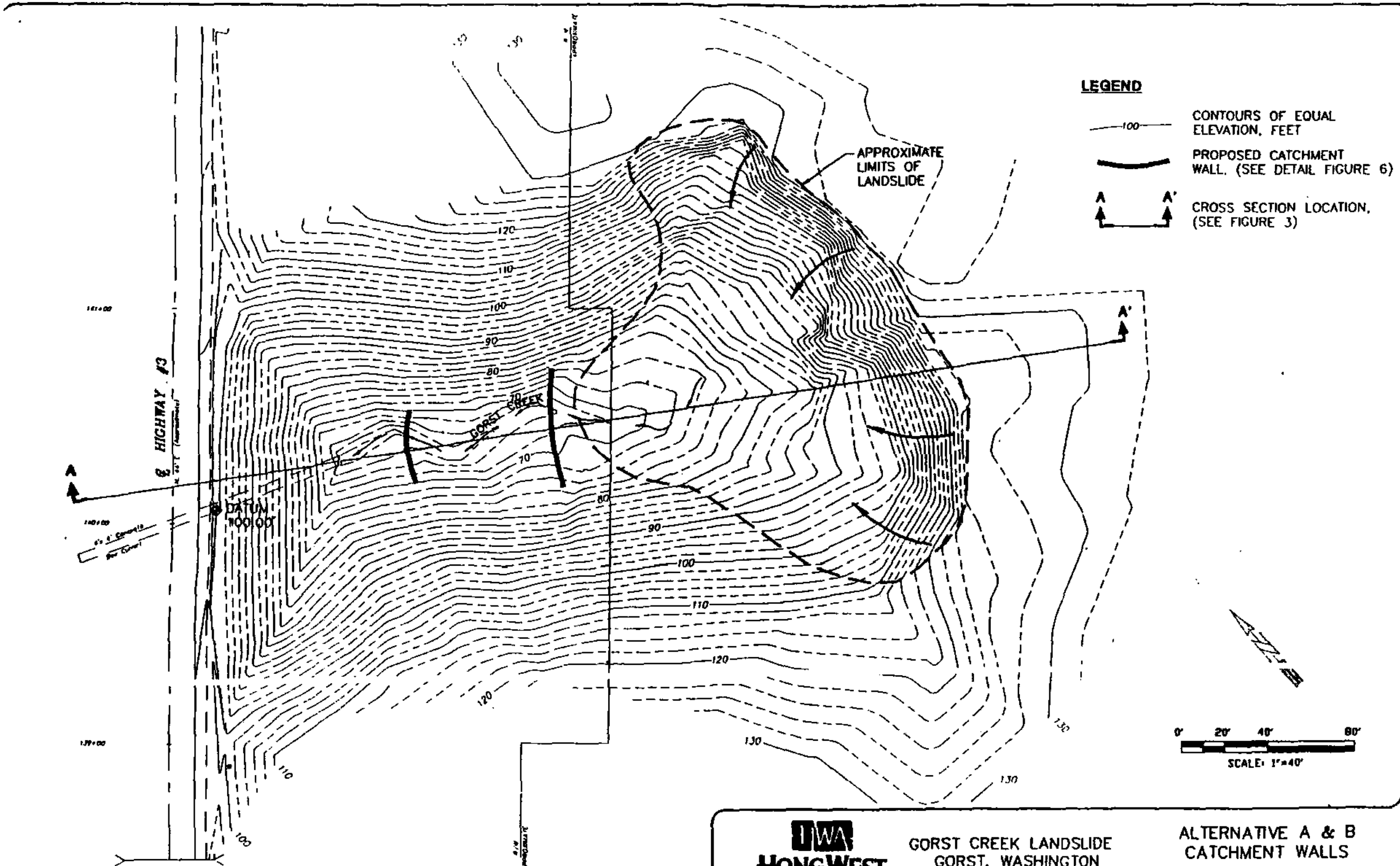
HONGWEST & ASSOCIATES, INC.

GORST CREEK LANDSLIDE
GORST, WASHINGTON

GENERALIZED PROFILE A–A'

PROJECT NO. 97063

FIGURE 3




HONGWEST & ASSOCIATES, INC.

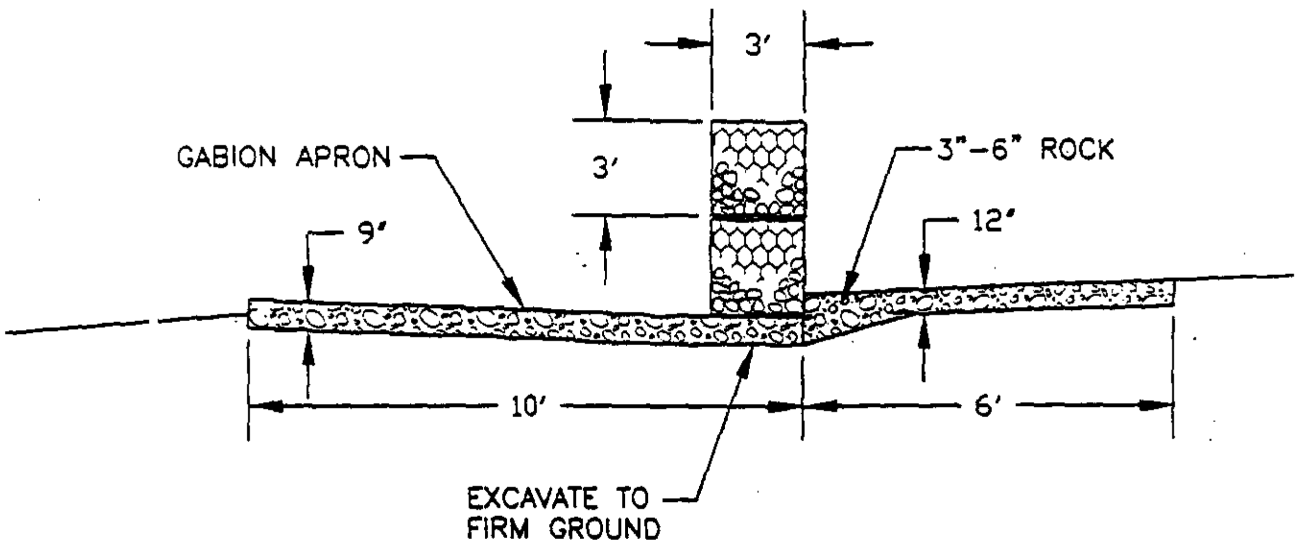
GORST CREEK LANDSLIDE
GORST, WASHINGTON

ALTERNATIVE A & B
CATCHMENT WALLS

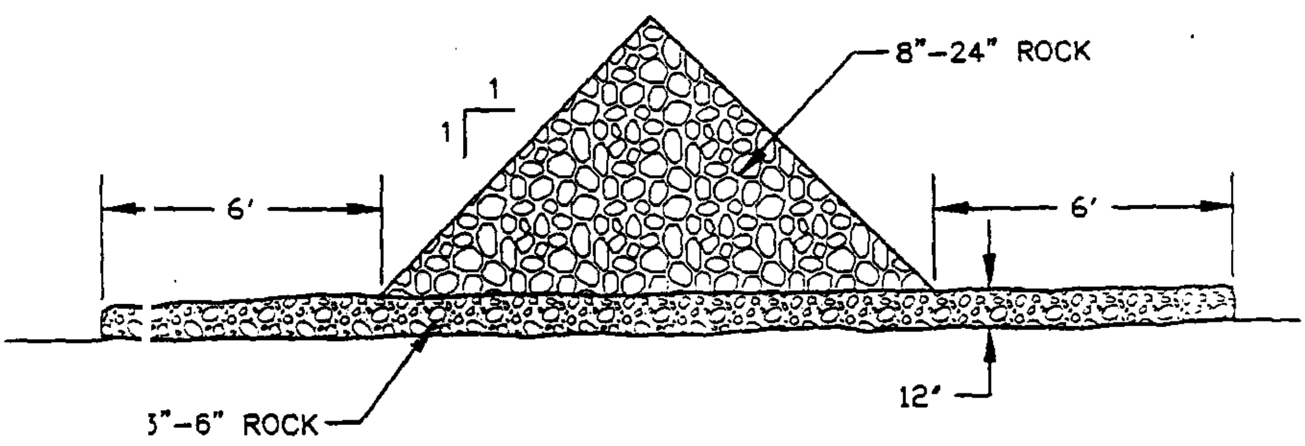
PROJECT NO. 97063 FIGURE 4

REFERENCE: Mapping provided by AES CONSULTANTS, Silverdale, Washington.

UPSLOPE DIRECTION




ALTERNATE A– GABION WALLS




ALTERNATE B– ROCK BARRIER

NOT TO SCALE

HONG WEST & ASSOCIATES, INC.

GORST CREEK LANDSLIDE
GORST, WASHINGTON

DETAIL OF
DEBRIS BARRIERS

PROJECT NO.: 97063 FIGURE 5

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